

How Long Can the Hubble Space Telescope Operate Reliably?

**M.A. Xapsos¹, C. Stauffer², T. Jordan³, C. Poivey⁴,
G. Lum⁵, D.N. Haskins¹, A.M. Pergosky⁵, D.C. Smith⁵
and K.A. LaBel¹**

¹NASA Goddard Space Flight Center, Greenbelt, MD, USA

²AS&D, Inc., Greenbelt, MD, USA

³EMP Consultants, Gaithersburg, MD, USA

⁴ESA-ESTEC, Noordwijk, The Netherlands

⁵Lockheed Martin, USA



Outline

- **Introduction**
- **Service Missions**
- **Total Dose Analysis and Results**
- **Other Potential Failure Mechanisms**
- **Summary**



Credit: <http://www.spacetelescope.org>



Introduction

- **Hubble Space Telescope (HST) deployed from Discovery April 25, 1990**
 - Low Earth Orbit, 590 km altitude, 28° inclination
 - First telescope designed to be serviced in space
- **Advantages in space:**
 - No atmospheric distortions
 - Little background light
 - Portions of ultraviolet and infrared spectra seen, not observable with Earth-based telescopes

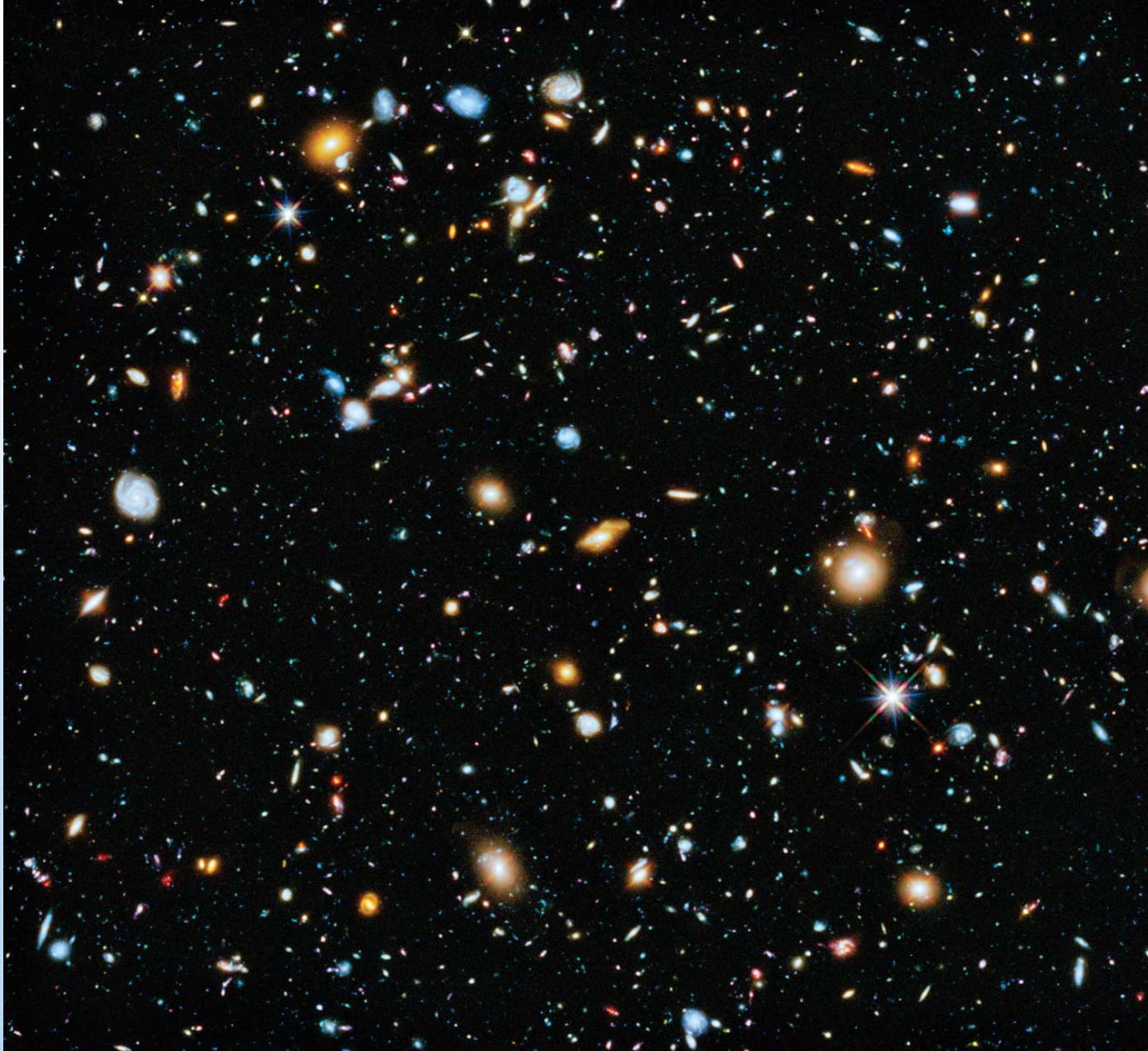
2.4 meter diameter primary mirror



Credit: <http://hubblesite.org/>



The Universe, Looking Back in Time



Credit: <http://hubblesite.org/>

To be presented by Michael A. Xapsos at the Institute of Electrical and Electronics Engineers (IEEE) Nuclear and Space Radiation Effects Conference (NSREC), Paris, France, July 14-18, 2014.



Service Mission 1 Corrective Optics

Galaxy M100, Before



Galaxy M100, After



Credit: <http://hubblesite.org/>



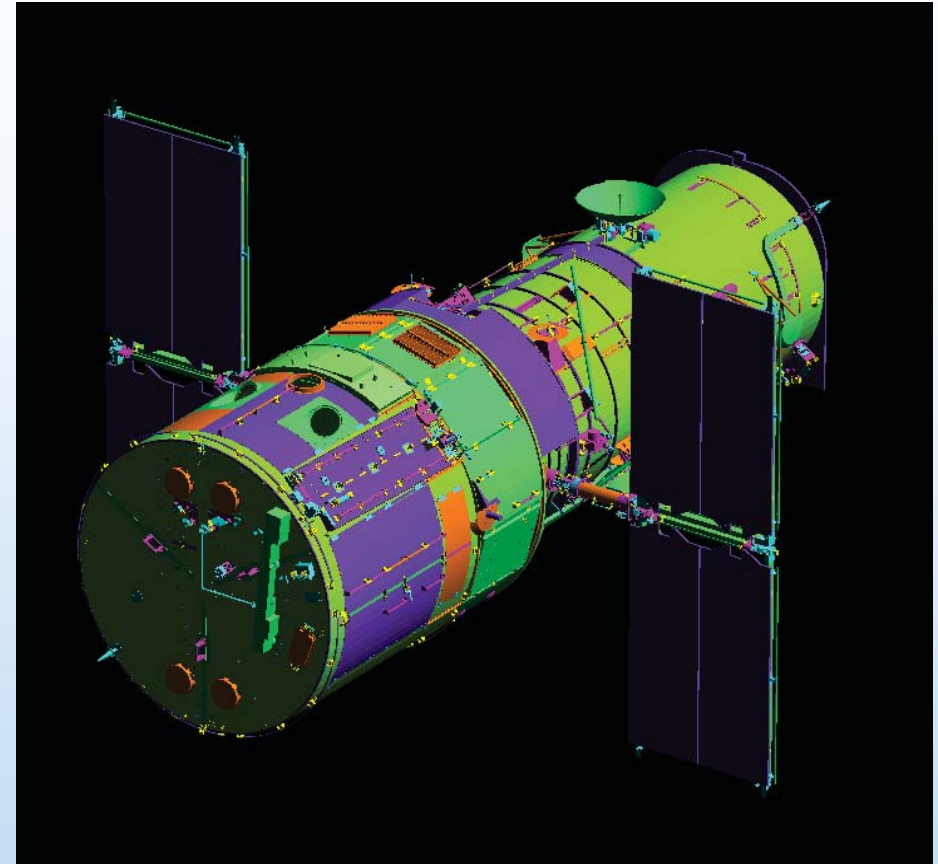
Desired HST Lifetime

- **Fifth and final HST servicing mission occurred in May 2009.**
 - Planning has been for one mission every 4 – 5 years
- **James Webb Space Telescope (JWST), the successor to HST, launches no sooner than 2018.**
- **Preferable that HST and JWST operate simultaneously for at least 1 – 2 years.**
- **Can HST continue reliable science operations until then?**
- **Main radiation concern is a hard failure due to total ionizing or non-ionizing dose.**
 - HST in orbit for 24 years



Total Dose Analysis

- **Used NOVICE code for 3-D ray trace and Monte Carlo radiation transport.**
 - Lockheed Martin spacecraft CAD model imported
 - Extensive review and implementation of subsystem and instrument dimensions, mass and placement
- **Used Boeing TPM-1 for trapped protons**
 - True solar cycle dependence
 - Service missions add another level of complexity to analysis
- **Used AE-8 for trapped electrons.**
 - Results insensitive to electron model

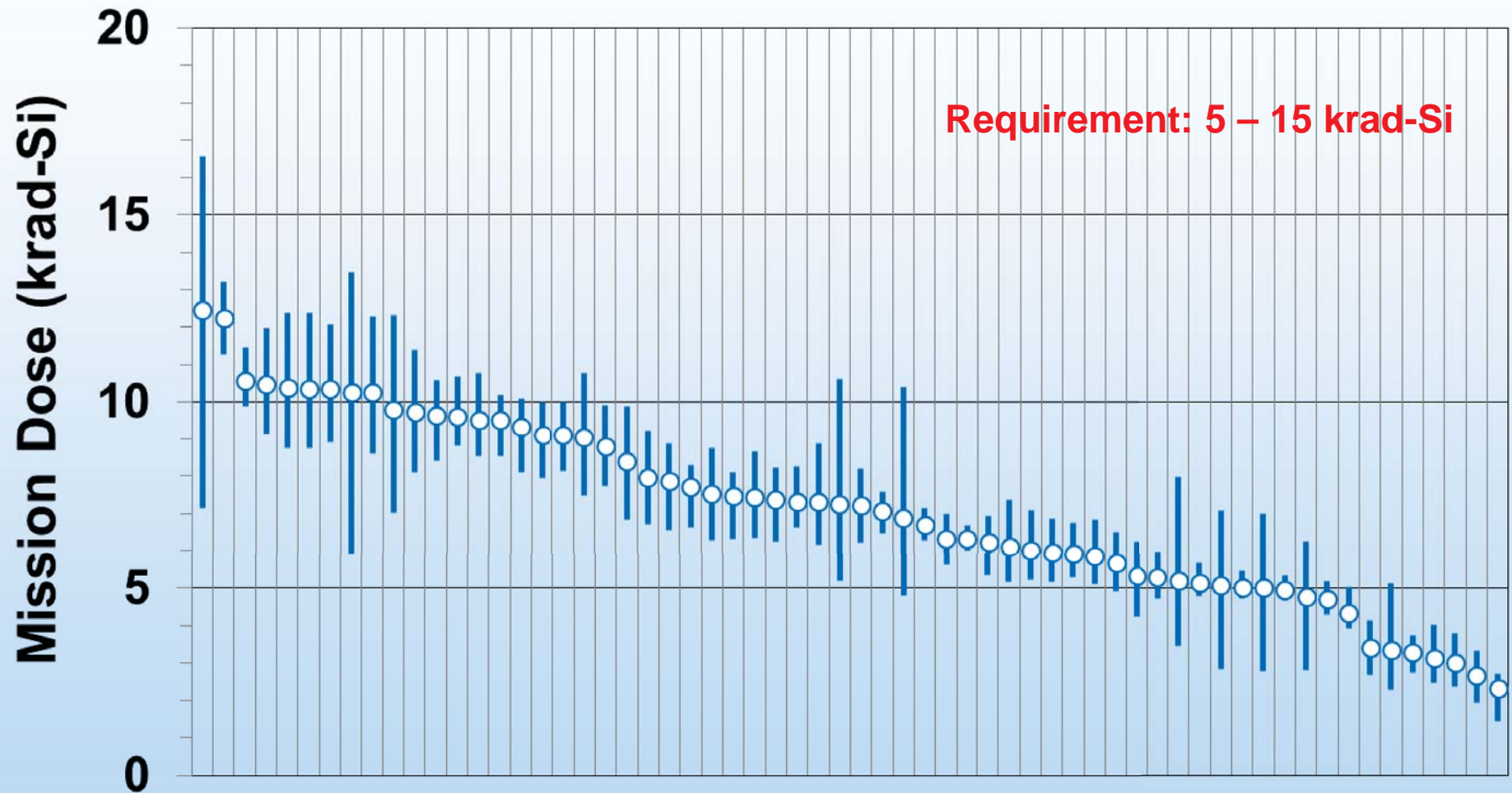


HST NOVICE Radiation Model



Expected Mission Dose in 2020

62 Subsystems / Instruments





Other Potential Failure Mechanisms

- **Gyroscopes**
 - 5 currently functional; 3 required
- **Fine Guidance Sensors**
 - 3 currently functional (1 barely); 2 required
- **Batteries**
 - 6 battery system expected to last ~ 10 years
 - All 6 replaced during 2009 servicing mission
- **Avionics System Reliability**
 - Predictive model shows 50% failure possibility in 2018, but is known to be conservative
- **Loss of Science Instruments**
 - Designed for 5 years but typically last longer
 - 2 installed in 2009 with full redundancy
 - 2 repaired in 2009, but now lack full redundancy



Summary

- **HST has been in orbit for about 24 years.**
- **A key goal is to keep science operations going for a year or two after JWST is launched.**
- **As a result of HST's longevity, total dose failures are an important consideration for continuation of the mission.**
 - **Just as significant as the other major potential failure modes.**



Acronyms

- **HST – Hubble Space Telescope**
- **JWST – James Webb Space Telescope**
- **NOVICE – Numerical Optimizations, Visualizations, and Integrations on CAD/CSG Edifices**
- **CAD – Computer Aided Design**
- **CSG – Constructive Solid Geometry**
- **3-D – three-dimensional**
- **TPM-1 – Trapped Proton Model-1**
- **AE-8 – Aerospace Electron Model-8**